

# 2651A

- **Source or sink:**
  - 2,000W of pulsed power ( $\pm 40V$ ,  $\pm 50A$ )
  - 200W of DC power ( $\pm 10V@ \pm 20A$ ,  $\pm 20V@ \pm 10A$ ,  $\pm 40V@ \pm 5A$ )
- Easily connect two units (in series or parallel) to create solutions up to  $\pm 100A$  or  $\pm 80V$
- 1pA resolution enables precise measurement of very low leakage currents
- 1 $\mu s$  per point (1MHz), continuous 18-bit sampling, accurately characterizes transient behavior
- 1% to 100% pulse duty cycle for pulse width modulated (PWM) drive schemes and device-specific drive stimulus
- Combines a precision power supply, current source, DMM, arbitrary waveform generator, V or I pulse generator with measurement, electronic load, and trigger controller—all in one instrument
- Includes TSP<sup>®</sup> Express characterization software, LabVIEW<sup>®</sup> driver, and Keithley's Test Script Builder software development environment

## APPLICATIONS

- Power semiconductor, HBLEd, and optical device characterization and testing
- Characterization of GaN, SiC, and other compound materials and devices
- Semiconductor junction temperature characterization
- High speed, high precision digitization
- Electromigration studies
- High current, high power device testing

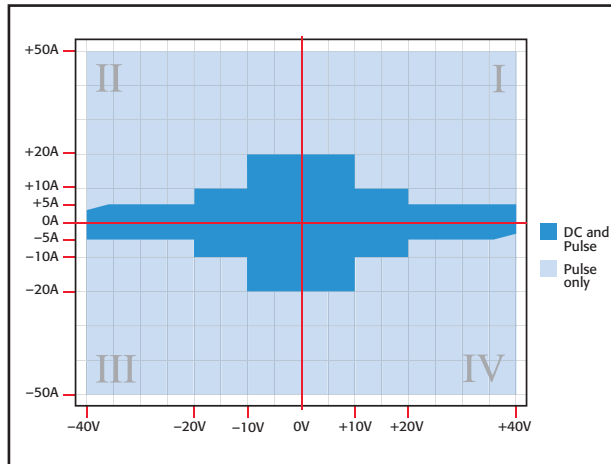
# High Power System SourceMeter<sup>®</sup> Instrument



The high power Model 2651A is the newest addition to the Series 2600A family of System SourceMeter instruments. Specifically designed to characterize and test high power electronics, it can help you improve productivity in applications across the R&D, reliability, and production spectrums, including high brightness LEDs, power semiconductors, DC-DC converters, batteries, and other high power materials, components, modules, and subassemblies.

The Model 2651A, like every Series 2600A SourceMeter instrument, offers a highly flexible, four-quadrant voltage and current source/load coupled with precision voltage and current meters. It can be used as a:

- Semiconductor characterization instrument
- V or I waveform generator
- V or I pulse generator
- Precision power supply
- True current source
- Digital multimeter (DCV, DCI, ohms, and power with 5 $\frac{1}{2}$ -digit resolution)
- Precision electronic load



## Two Measurement Modes: Digitizing or Integrating

Precisely characterize transient and steady-state behavior, including rapidly changing thermal effects, with the two measurement modes in the Model 2651A. Each mode is defined by its independent analog-to-digital (A/D) converters.

Captures 1,000,000 readings/second, continuous 1 $\mu s$  per point sampling, in the Digitizing Measurement mode. Its 18-bit A/D converters allow you to precisely measure transient characteristics. For more accurate measurements, use its Integrating Measurement mode, which is based on 22-bit A/D converters. The Integrating Measurement mode is provided in all Series 2600A instruments.

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## Ordering information

**2651A High Power System SourceMeter® Instrument**

### Accessories Supplied

**2651A-KIT-1A: Low Impedance Cable Assembly (1m)**

**CS-1592-2: High Current Phoenix Connector (male)**

**CS-1626-2: High Current Phoenix Connector (female)**

**CA-557-1: Sense Line Cable Assembly (1m)**

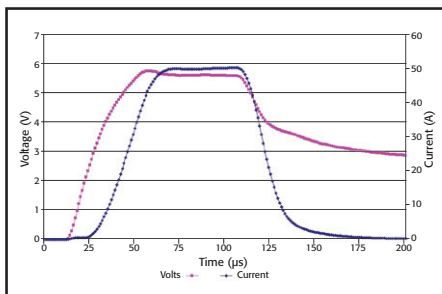
**7709-308A: Digital I/O Connector**

**CA-180-3A: TSP-Link/Ethernet Cable**

**Documentation CD**

**Software Tools and Drivers CD**

Two A/D converters are used with each measurement mode (one for current and the other for voltage) which run simultaneously for accurate source readback that does not sacrifice test throughput.



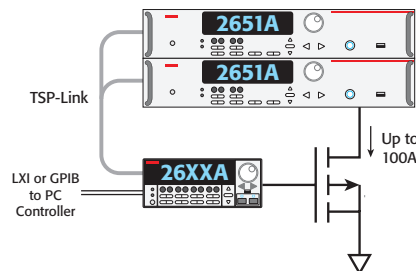
The dual digitizing A/D converters continuously sample at up to 1µs/point, enabling full simultaneous characterization of both current and voltage waveforms.

## High Speed Pulsing

The Model 2651A minimizes the unwanted effects of self heating during tests by accurately sourcing and measuring pulses as short as 100µs. Additional control flexibility enables you to program the pulse width from 100µs to DC and the duty cycle from 1% to 100%. A single unit can pulse up to 50A; combine two units to pulse up to 100A.

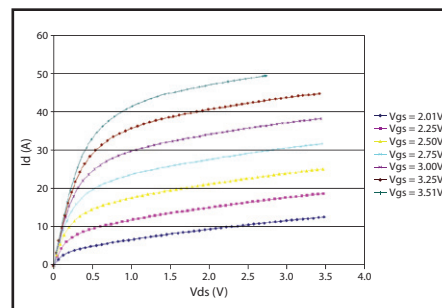
## Expansion Capabilities

Through TSP-Link® technology, multiple Model 2651As and other Series 2600A instruments can be combined to form a larger integrated system with up to 64 channels. Precision timing and tight channel synchronization are guaranteed with built-in 500ns trigger controllers. True SMU-per-pin testing is assured with the fully isolated, independent channels of the SourceMeter instruments.

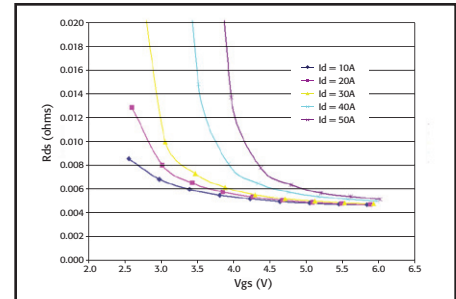


Keithley's TSP and TSP-Link technology enables true SMU-per-pin testing without the power and/or channel limitations of a mainframe-based system.

Also, when two Model 2651As are connected in parallel with TSP-Link, the current range is expanded from 50A to 100A. When two units are connected in series, the voltage range is expanded from 40V to 80V. Built-in intelligence simplifies testing by enabling the units to be addressed as a single instrument, thus creating an industry-best dynamic range (100A to 1pA). This capability enables you to test a much wider range of power semiconductors and other devices.



Precision measurements to 50A (100A with two units) enable a more complete and accurate characterization.



1µV measurement resolution and current sourcing up to 50A (100A with two units) enable low-level Rds measurements to support next-generation devices.

## Standard Capabilities of Series 2600A Instruments

Each Model 2651A includes all the features and capabilities provided in the other Series 2600A instruments, such as:

- Ability to be used as either a bench-top I-V characterization tool or as a building block component of multiple-channel I-V test systems
- TSP Express software to quickly and easily perform common I-V tests without programming or installing software
- ACS Basic Edition software for semiconductor component characterization (optional). ACS Basic now features a Trace mode for generating a suite of characteristic curves.
- Keithley's Test Script Processor (TSP®), which enables creation of custom user test scripts to further automate testing, and also supports the creation of programming sequences that allow the instrument to operate asynchronously without direct PC control.
- Parallel test execution and precision timing when multiple Series 2600A instruments are connected together in a system
- LXI class C compliance
- 14 digital I/O lines for direct interaction with probe stations, component handlers, or other automation tools
- USB port for extra data and test program storage via USB memory device

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## Condensed Specifications

### VOLTAGE ACCURACY

Range	Source		Measure		
	Programming Resolution	Accuracy ±(%rdg. + volts)	Display Resolution	Integrating ADC Accuracy ±(%rdg. + volts)	High Speed ADC Accuracy ±(%rdg. + volts)
100.000 mV	5 µV	0.02% + 500 µV	1 µV	0.015% + 300 µV	0.015% + 600 µV
1.00000 V	50 µV	0.02% + 500 µV	10 µV	0.015% + 300 µV	0.015% + 600 µV
10.0000 V	500 µV	0.02% + 5 mV	100 µV	0.015% + 3 mV	0.015% + 8 mV
20.0000 V	500 µV	0.02% + 5 mV	100 µV	0.015% + 3 mV	0.015% + 8 mV
40.0000 V	500 µV	0.02% + 12 mV	100 µV	0.015% + 8 mV	0.015% + 15 mV

### CURRENT ACCURACY

Range	Source		Measure		
	Programming Resolution	Accuracy ±(%rdg. + amps)	Display Resolution	Integrating ADC Accuracy ±(%rdg. + amps)	High Speed ADC Accuracy ±(%rdg. + amps)
100.000 nA	2 pA	0.1 % + 500 pA	1 pA	0.08% + 500 pA	0.08% + 800 pA
1.00000 µA	20 pA	0.1 % + 2 nA	10 pA	0.08% + 2 nA	0.08% + 4 nA
10.0000 µA	200 pA	0.1 % + 10 nA	100 pA	0.08% + 8 nA	0.08% + 10 nA
100.000 µA	2 nA	0.03% + 60 nA	1 nA	0.02% + 25 nA	0.02% + 60 nA
1.00000 mA	20 nA	0.03% + 300 nA	10 nA	0.02% + 200 nA	0.02% + 500 nA
10.0000 mA	200 nA	0.03% + 6 µA	100 nA	0.02% + 2.5 µA	0.02% + 10 µA
100.000 mA	2 µA	0.03% + 30 µA	1 µA	0.02% + 20 µA	0.02% + 50 µA
1.00000 A	200 µA	0.08% + 3.5 mA	10 µA	0.05% + 3 mA	0.05% + 5 mA
5.00000 A	200 µA	0.08% + 3.5 mA	10 µA	0.05% + 3 mA	0.05% + 5 mA
10.0000 A	200 µA	0.08% + 6 mA	100 µA	0.05% + 6 mA	0.05% + 12 mA
20.0000 A	500 µA	0.08% + 8 mA	100 µA	0.05% + 8 mA	0.05% + 15 mA
50.0000 A	2 mA	0.08% + 50 mA	100 µA	0.05% + 50 mA	0.05% + 90 mA

### ADDITIONAL SOURCE SPECIFICATIONS

NOISE(10HZ–20MHZ): <100mV peak-peak (typical), <30mV RMS (typical).

OVERSHOOT: Voltage:  $\leq \pm(0.1\% + 10\text{mV})$  (typical).  
Current:  $\leq \pm 0.1\%$  (typical).

#### REMOTE SENSE OPERATING RANGE:

Maximum voltage between HI and SENSE HI = 3V  
Maximum voltage between LO and SENSE LO = 3V

VOLTAGE SOURCE OUTPUT SETTLING TIME: <50µs best range.

CURRENT SOURCE OUTPUT SETTLING TIME: <80µs best range.

MAXIMUM IMPEDANCE PER SOURCE LEAD: Maximum impedance limited by 3V drop by Remote Sense Operating Range.

Maximum Resistance = 3V/Source Current Value (Amps).  
 $3\text{V} = I \cdot R$

### ADDITIONAL METER SPECIFICATIONS

MAXIMUM LOAD IMPEDANCE:

Normal Mode: 10nF (typical), 3µH (typical).

High Capacitance Mode: 50µF (typical), 3µH (typical).

MEASURE INPUT IMPEDANCE: >10GΩ.

COMMON MODE VOLTAGE: 250 VDC.

CONTACT CHECK: Built-in.

### MEASUREMENT SPEED SPECIFICATIONS

#### MAXIMUM SWEEP OPERATION RATES (operations per second) FOR 60Hz (50Hz):

A/D Converter Speed	Trigger Origin	Measure to Memory via user scripts	Measure to GPIB via user scripts	Source Measure to Memory via user scripts	Source Measure to GPIB via user scripts	Source Measure to Memory using sweep API	Source Measure to GPIB using sweep API
0.001 NPLC	Internal	20000 (20000)	10000 (10000)	7000 (7000)	6200 (6200)	12000 (12000)	5900 (5900)
0.001 NPLC	Digital I/O	8100 (8100)	7100 (7100)	5500 (5500)	5100 (5100)	11200 (11200)	5700 (5700)
0.1 NPLC	Internal	580 (480)	560 (470)	550 (465)	550 (460)	560 (470)	545 (460)
1.0 NPLC	Internal	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)	59 (49)
HS ADC	Internal	38500 (38500)	20000 (20000)	10000 (10000)	9500 (9500)	14300 (14300)	6300 (6300)

#### MAXIMUM SINGLE MEASUREMENT RATES (operations per second) FOR 60Hz (50Hz):

A/D Converter Speed	Trigger Origin	Measure to GPIB	Source Measure to GPIB	Source Measure Pass/Fail to GPIB
0.001 NPLC	Internal	1900 (1800)	1400 (1400)	1400 (1400)
1.0 NPLC	Internal	58 (48)	57 (48)	57 (48)

MINIMUM MEASUREMENT RANGE CHANGE: 143µs

MINIMUM SOURCE RANGE CHANGE: 2.5 ms

MINIMUM SOURCE FUNCTION RANGE CHANGE: 1.0 ms

### POWER SPECIFICATIONS

#### MAXIMUM OUTPUT POWER AND SOURCE/SINK LIMITS:

VOLTAGE	CURRENT
202 W maximum	202 W maximum
±10.1 V @ ±20.0 A	± 5.05 A @ ± 40 V
±20.2 V @ ±10.0 A	± 10.1 A @ ± 20 V
±40.4 V @ ± 5.0 A	± 20.2 A @ ± 10 V
Four-quadrant source or sink operation.	Four-quadrant source or sink operation

CURRENT AND VOLTAGE RANGE EXPANSION: Two Model 2651A units can be combined in series or parallel to expand the operating ranges and power performance for some applications. Refer to www.keithley.com for the necessary application notes.

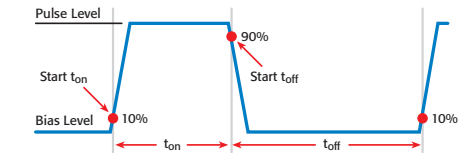
ACTIVE LOAD OPERATION: CAUTION: Using the Model 2651A in combination with another System SourceMeter® instrument or any other active load requires that the Model 2651A has the output off mode set to "OUTPUT\_ACTIVE\_LOAD". See the 2651A Reference Manual for additional details.

### PULSE SPECIFICATIONS

MINIMUM PROGRAMMABLE PULSE WIDTH: 100µs.

PULSE WIDTH PROGRAMMING RESOLUTION: 1µs.

MEASURED FROM THE START OF PULSE TO THE START OF OFF-TIME:



#### MINIMUM PULSE RISE TIME:

Current Range	Rload	Rise Time (typical)
50 A	0.05 Ω	25 µs
50 A	0.2 Ω	57 µs
50 A	0.4 Ω	85 µs
20 A	0.5 Ω	90 µs
50 A	0.8 Ω	120 µs
20 A	1 Ω	180 µs
10 A	2 Ω	330 µs
5 A	8.2 Ω	400 µs

DUTY CYCLE: 1%–100%

#### HIGH SPEED ADC BURST MEASUREMENT RATES:

Burst Length (rdgs.)	Readings/s	Bursts/s
100	1M	400
500	1M	80
1000	1M	40
2500	1M	16
5000	1M	8

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## TRIGGERING AND SYNCHRONIZATION SPECIFICATIONS

**TRIGGERING:** Trigger in to Trigger Out: 0.5µs, typical.

**SYNCHRONIZATION:** Single- or multi-node synchronized source change: <0.5µs, typical.

## PROGRAMMING

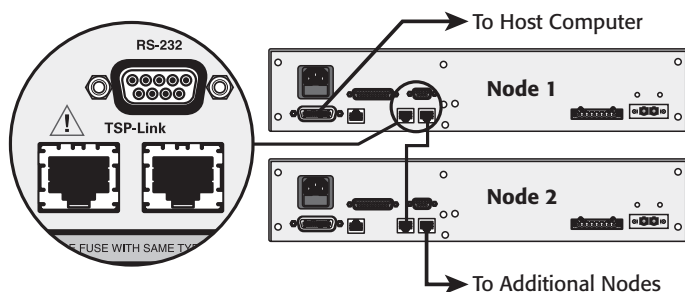
**TEST SCRIPT BUILDER:** Integrated development environment for building, running, and managing TSP scripts.

**TSP EXPRESS (EMBEDDED):** Tool that allows users to quickly and easily perform common I-V tests without programming or installing software.

**OTHER SOFTWARE INTERFACES:** TSP Express (Embedded), Direct GPIB/VISA, Read/Write with VB, VC/C++, VC#, LabVIEW, LabWindows/CVI, etc.

## SYSTEM EXPANSION

The TSP-Link expansion interface allows TSP-enabled instruments to trigger and communicate with each other. See figure below:



## GENERAL

**USB:** USB 2.1 Host Controller, supports external data storage.

**CONTACT CHECK:** 1ms minimum measurement time; 5% basic accuracy.

**PC INTERFACE:** IEEE-488.1 and .2; LXI Class C Ethernet; RS-232.

**DIGITAL I/O INTERFACE:** Input/Output Pins: 14 open drain I/O bits. 5.25V max.

**POWER SUPPLY:** 100 V to 250 VAC, 50 Hz – 60 Hz (auto sensing), 550 VA max

**COOLING:** Forced air. Side and top intake and rear exhaust.

**EMC:** Conforms to European Union EMC Directive.

**SAFETY:** UL listed to UL61010-1:2004 (PENDING). Conforms to European Union Low Voltage Directive.

**WARRANTY:** 1 year.

**DIMENSIONS:** 89mm high × 435mm wide × 549mm deep (3.5 in × 17.1 in × 21.6 in). Bench Configuration (with handle & feet): 104mm high × 483mm wide × 620mm deep (4.1 in × 19 in × 24.4 in)

**WEIGHT:** 9.98kg (22 lbs).

**ENVIRONMENT:** For indoor use only.

**CALIBRATION PERIOD:** One year.



The Model 2651A supports GPIB, LXI, Digital I/O, and Keithley's TSP-Link for multi-channel synchronization.

Specifications are subject to change without notice.

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